Imperial College London

Sustainable Energy Futures Conference 2019

13 September 2019

SELL, STORE OR MINE: INTELLIGENT DECISION-MAKING FOR RENEWABLE ENERGY

13

STUDENT: JOANA BARRAGAN CIRNE

SUPERVISORS: Professor William Knottenbelt

(Department of Computing, Imperial College London)

For further information **scan me!**

NEW REVENUE STREAMS FOR RENEWABLE ENERGY

Cost parity between renewables and fossil fuels has become the holy grail of the energy sector. Particularly, **solar PV still struggles to overcome economic hurdles** and heavily relies on subsidies and special solar tariffs. This thesis suggests that **current financial models for solar energy require new revenue streams**, as well as business models' flexibility to maximise profitability based on specific market conditions and geographical location characteristics.

PROJECT OBJECTIVES

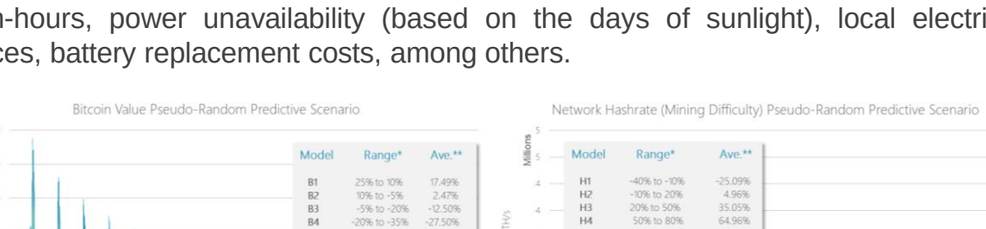
The overarching aim of this thesis was to analyse different revenue streams for solar PV site in different countries, entailing different resource profiles and energy market conditions.

1. To compare how different **geographical and market conditions** influence on the suitability of a particular system and its capacity to generate profit.
2. To identify the potential in crypto-mining to make **solar PV a naturally-attractive investment choice** (subsidy-free, no special solar tariffs).
3. To develop a **predictive analysis of the Bitcoin network** based on pseudo-random scenarios and simulate the impact on profitability.

Three different scenarios are explored in three different countries.

		☀	⚡	▦	🔋
SCENARIO 1	Selling the electricity generated to the grid	✓	✓	–	–
SCENARIO 2	Allocating the electricity generated to Bitcoin mining and selling electricity surplus to the grid	✓	✓	✓	–
SCENARIO 3	Allocating the electricity generated to Bitcoin mining and storing electricity surplus while continuing to generate profit through mining	✓	–	✓	✓

Icons indicate solar PV, grid, cryptomining and energy storage.



Figures not drawn to scale.

METHODOLOGY

For the purpose of this thesis, several models have been developed, which were in some cases interdependent (Fig 3).

- The solar PV model for each country was comprehensively integrated using the GIS software PVSyst 6.8.3, **including technical and profitability aspects** which were later assessed.
- The mining model comprised the assumptions with regards to the mining technology, the future prediction of the Bitcoin value and network hashrate, and the resulting profitability. The **Bitcoin forecasting was performed across five future scenarios** (Fig 1 and 2).
- The energy storage (ES) model defined the surplus electricity generated by the PV during the years based on a fixed number of miners settings that would increase the ROI. The most **optimal battery configuration** is selected.

The financial analysis includes several **sensitivity analyses** with variables such as sun-hours, power unavailability (based on the days of sunlight), local electricity prices, battery replacement costs, among others.

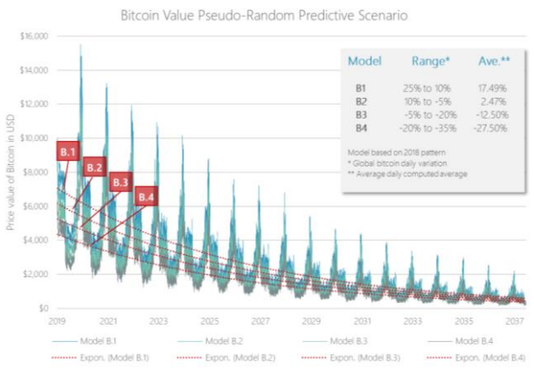


Figure 1. Bitcoin price value prediction scenarios

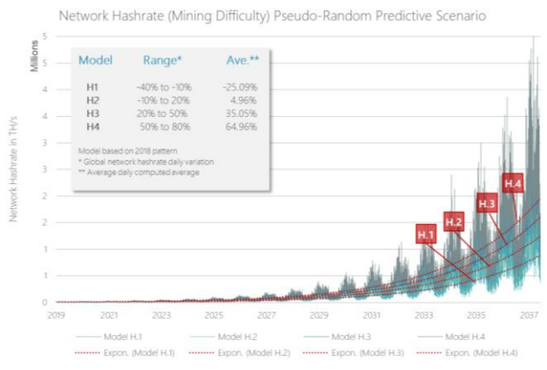


Figure 2. Network hashrate prediction scenarios

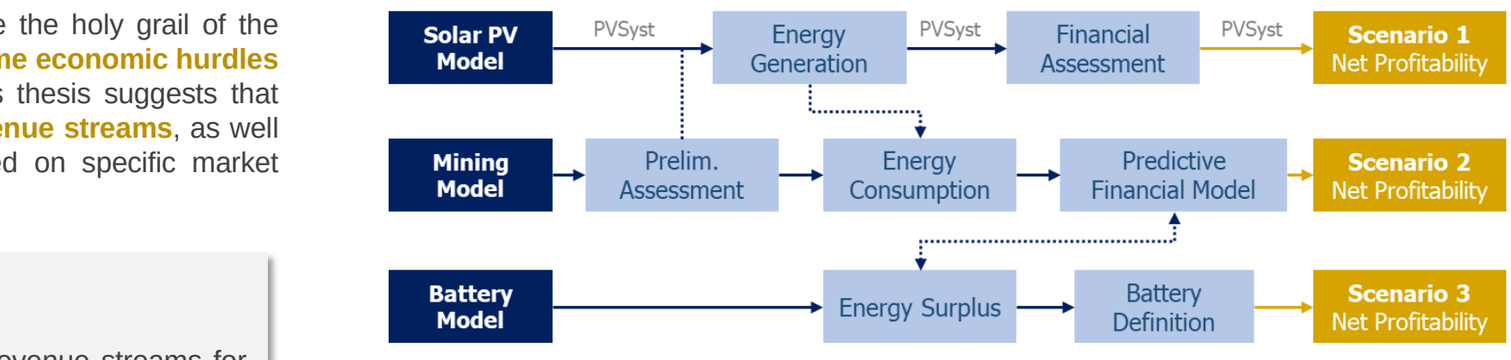


Figure 3

MAIN FINDINGS

1. Energy market conditions affect PV profitability more than geographical for countries within a same PV class

At the same technological conditions, Huelva in Spain, whilst producing yearly 10.2% more energy than Panjib in India, cumulatively it does not render the project profit when selling to the grid (Fig 4). This is due to the fact that in Spain solar energy competes against electricity generated from conventional sources.

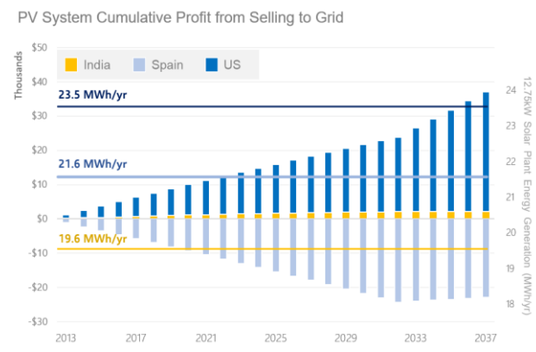


Figure 4

2. Cryptomining can make investment in solar PV worth it

Bitcoin mining presents itself as a revenue stream that can maximize profit in the 25-year length of a solar PV site lifetime, as seen in Scenario 2 (Fig 6). Particularly, it was observed that whilst Huelva could not make its solar PV site profitable (Fig 4), it benefits the most with regards to cryptomining potential as it has the largest rate of power availability in comparison to the other analysed countries.

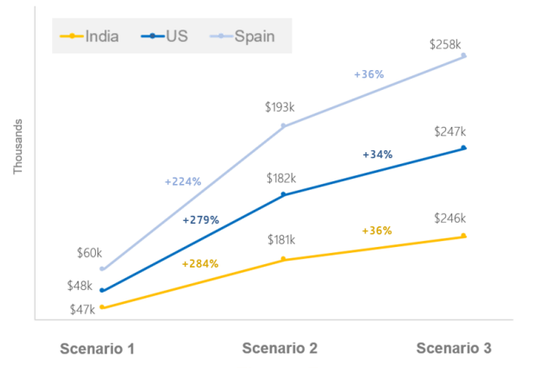
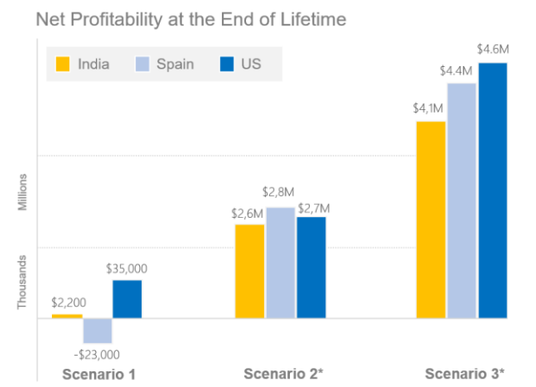


Figure 5

3. Energy storage can spur profitability through cryptomining

Based on Bitcoin prediction results, cryptomining presents itself very profitable to all three countries and investing in energy storage increases the profitability from Scenario 2 by 56%, 59% and 70% for Panjib, Huelva and Barstow, respectively, despite the increased net investment observed for Scenario 3 (Fig 5).



*Values presented as an average of the predictive model results

Figure 6

SO WHAT? Currently, PV deployment highly depends on the surrounding energy market conditions. The need for financially-logical business models emanate at times where renewables' competitive advantage is not clearly laid out against conventional sources.

Profitability coming from new revenue streams such as cryptomining can potentially spur investment towards solar PV installation and other renewable technologies and provide a safety net for generators that seek a return on investment. Flexible models are envisioned to guarantee that clean electricity reaches the grid, whilst allowing PV generators to make substantial profit on their investment.

ACKNOWLEDGEMENTS

I express my most sincere gratitude to my supervisor Professor William Knottenbelt, who has put great efforts in finding a project that would be both stirring and challenging. I'd like to extend my gratitude to Gavin Eves for his outstanding disposition in supporting our class. I dedicate my efforts to my fellow classmates with whom I have had the chance to share great moments throughout the course of this Master's, to Ernesto José Petit Masci for his kind and unwavering support throughout, as well as to my family who never ceases to support me in all aspects of my life. All to whom I would like to express my heart-felt gratitude.

energy futures lab